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Pre-analytical Errors in Haematology Laboratory of a Tertiary Care Hospital: A Cross-Sectional Study of northern Pakistan

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ABSTRACT

Objective: To identify the types and frequency of pre-analytical errors in the haematology laboratory and to reduce these pre-analytical errors by taking corrective measures.

Study Design: Cross-sectional study.

Place and Duration of Study: Haematology Laboratory of Pak Emirates Military Hospital, Rawalpindi Pakistan, from Mar to Apr 2022 after applying corrective measures, pre-analytical errors were re-analysed from Jun to Jul 2022.

Methodology: The study included all samples received in the haematology laboratory for complete blood count, peripheral blood smear, coagulation profile, and blood malarial parasite. Blood samples were checked for clotted samples, insufficient quantity, diluted samples, hemolysed samples, lipemic samples, and degenerated samples. After that, corrective measures were taken to reduce the pre-analytical errors.

Results: The total number of samples received in the first session was 30,169, and pre-analytical errors were present in 508(0.016%) samples. The most frequent pre-analytical errors were of clotted samples 300(59.1%) followed by quantity not sufficient 168(33.1%), hemolysed samples 68(13.4%), diluted samples 49(9.6%), degenerated samples 22(4.3%) and lipemic samples 18(3.5%). After applying corrective measures, pre-analytical errors were reduced in clotted samples 78(52.7%), quantity not sufficient 39(26.4%), hemolysed samples 14(9.5%), diluted samples 11(7.4%), degenerated samples 5(3.4%) and lipemic samples 4(2.7%) respectively.

Conclusion: This study showed the relative frequency of various pre-analytical errors in a haematology laboratory. It also signifies the implementation of corrective measures for reducing these pre-analytical errors.

Keywords: Hemolysed Sample, Lipemic Sample, Pre-analytical errors, Blood, Blood cell count, Pakistan.

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INTRODUCTION

Management of quality control is an integral factor of any laboratory for maintenance of its meticulousness, accuracy and error reduction.[1] Around 60-70% of decisions concerning patient admission and discharge in hospitals are based on laboratory data.[2] Blood sample testing in haematology laboratory includes three phases, i.e., pre-analytical, analytical and post-analytical. Pre-analytical phase includes all procedures from the time of making laboratory request form from the doctor until the sample is readily available for appropriate tests.[3] The pre-analytical phase is frequently the major basis of incorrect laboratory tests with a frequency of about 1/3rd-3/4th of errors in laboratory being attributed to this phase.[4] Pre-analytical errors can impact both analytical and post-analytical steps.[5] Pre-analytical errors can occur due to various reasons which include misidentification of the patient, wrong venipuncture, inadequate sample collection, clotted sample, diluted sample, hemolysed sample, contaminated container, improper storage and transport of sample.[6] Pre-analytical errors have wide range of influence i.e., from awkwardness of repeating the same test again to life-threatening blood transfusion reaction due to mismatched blood.[7,8]

Pre-analytical errors are preventable because they can be inhibited by the proper training and applying appropriate quality control techniques in all stages of the sample collection and test procedures. Improper phlebotomy techniques due to improper training are among the chief causes of pre-analytical errors. All employees should be required to take continuing education classes to ensure that not only are they familiar with current procedures but that they become aware of any changes that can serve to reduce the risk of this type of error occurring.[9] Appropriate and

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judicious acknowledgement of these errors in quality control will help in improving therapeutic approach and care of patient.[10]

Various international studies have been carried out regarding pre-analytical error. Most of them have revealed the type and frequency of pre-analytical errors, but hardly any have discussed the impact of corrective measures on pre-analytical errors. This study was conducted to identify the types and frequency of pre-analytical errors in the haematology laboratory and to reduce these pre-analytical errors by taking necessary corrective measures.

METHODOLOGY

The cross-sectional study was carried out at the Haematology Laboratory of the Pak Emirates Military Hospital, Rawalpindi, Pakistan after approval from the Ethical Review Committee (ERC/ID/215). The results were analysed in two sessions. The first session was from March 2022 to April 2022 for two months before applying corrective measures. The second session was from June 2022 to July 2022, and it included samples after implementing corrective measures such as using paediatric tubes, educating phlebotomists and proper transportation of samples. Pre-analytical errors were then re-analysed to estimate the improvement in these errors. The sample size was calculated using the WHO sample size calculator, taking the reported prevalence of pre-analytical errors of 46%.[11]

Inclusion Criteria: The study included all samples received in the haematology laboratory for complete blood count, peripheral blood smear, coagulation profile, and blood malarial parasites from Inpatient and Outpatient Departments.

Exclusion Criteria: Samples for bone marrow biopsy and fluid samples like cerebrospinal fluid (CSF) pleural, peritoneal, etc., were excluded.

This study included 508 samples with pre-analytical lab errors. Sample collection was done in EDTA vacutainers for plasma, blood, and trisodium citrate vacutainers for coagulation profile. Sysmex XP100 analysed all samples for complete blood count, while Mindray 3510 haematology auto analysers analysed samples for coagulation profile samples. All tests were conducted within 4 hours of sample collection. All confounding variables were minimised using test tubes from the same manufacturer, and the nursing staff doing phlebotomy remained unchanged during the study period. Standard techniques for drawing blood samples, transportation of blood samples and pre-analytical error registration also stayed unaffected before and after applying corrective measures.

Blood samples were checked for clotted samples, quantity not sufficient, diluted samples, hemolysed samples, lipemic samples and degenerated samples. After that, corrective measures were taken to reduce the pre-analytical errors. All samples were analysed for pre-analytical quality errors and documentation were made in the register before the analysis. Firstly, paediatric tubes were used to reduce the error of insufficient blood samples taken from paediatric wards. Secondly, details of the proper methods for sample collection and handling were provided to phlebotomists and laboratory technicians, such as the choice of collection tubes for different tests, the order of draw for sample collection, the appropriate ratio of blood to anticoagulant in samples, and the proper labelling, transportation and storage of samples to reduce pre-analytical errors such as hemolysed samples, diluted samples and clotted samples as shown in Table-I.

Table-I Measures taken to correct pre-analytical errors

Preanalytical Errors	Corrective Actions
Clotted samples	Proper training of phlebotomy staff, proper mixing and appropriate ratio of blood to anticoagulant
QNS	Use of paediatric tubes in paeds wards
Hemolyzed samples	Proper mixing of blood and training of phlebotomy staff about proper techniques of phlebotomy
Diluted samples	Proper training of phlebotomy staff (take blood from arm opposite to IV line)
Degenerated samples	Proper processing of blood samples within 4hours of blood collection
Lipemic samples	Proper training of technicians regarding history taking of drug intake.

Statistical analysis was performed using the Statistical Package for Social Sciences version 22. The frequency of each type of pre-analytical error was assessed. Percentage was used for descriptive statistics to explain the distribution. The data was analysed by

comparing the pre-analytical errors before and after corrective measures were taken, and variance was shown by relative risk estimation.

RESULTS

A total of 30169 samples were received in the Haematology Laboratory from March to April 2022 before the application of corrective measures. Pre-analytical errors during this phase were present in 508 samples. Therefore, the frequency of pre-analytical errors was 0.016%. Out of the total samples, clotted samples were 300(59.1%) and the quantity not sufficient were 168(33.1%) samples. They were followed by hemolysed 68(13.4%)and diluted 49(9.6%) samples. The least common pre-analytical errors found in the haematology laboratory were degenerated sample 22(4.3%) and lipemic sample 18(3.5%), as shown in Table-II.

Table-II Frequency of Pre-Analytical Errors Before after Implementation of Corrective Measures (n=656)

Types of pre-analytical errors	Frequeny of errors before corrective measures (%) n=508	Frequeny of errors after correctivem easures (%) n=148	Relative risk
Clotted sample	300(59.%)	78(52.7%)	1.29
QNS	168(33.1%)	39(26.4%)	1.38
Hemolyzed sample	68(13.4%)	14(9.5%)	1.33
Diluted sample	49(9.6%)	11(7.4%)	1.48
Degenerated sample	22(4.3%)	5(3.4%)	1.32
Lipemic sample	18(3.5%)	4(2.7%)	1.29

After applying corrective measures, about 29850 samples were received in the haematology laboratory from June to July 2022. During this phase, pre-analytical errors were present in 148 samples. Hence, the frequency of pre-analytical errors was 0.004%. Out of the total samples with pre-analytical errors, clotted samples were reduced to 78(52.7%), and samples of insufficient quantity were reduced to 39 (26.4%). The decrement in hemolysed and diluted samples was 14(9.5%) and 11(7.4%) respectively. Degenerated and lipemic samples were reduced to 5(3.4%) and 4(2.7%) correspondingly.

DISCUSSION

With the advancement in science and technology, there is growing acceptance that a clinical laboratory cannot achieve 'reliability' by converging on the analytical phase of the testing process. The pre-analytical and post-analytical phases of laboratory testing are equally important to attain consistency in results.[12] Nonetheless, the challenges faced during the pre-analytical phase of testing are diverse yet controllable, ranging from improper blood collection by the staff to clotted blood samples. In the present study, the total number of samples received in the haematology laboratory during the first session of nine months' duration was 30169, and a total of 508 samples had pre-analytical errors. A similar study conducted by Arul *et al*. showed pre-analytical error in 513 samples out of a total of 118,732 samples, which was found to be 0. 43% of the total samples received in the present study. The frequency of pre-analytical errors was 0.016%.[13]

The present study also observed the various causes of pre-analytical errors in laboratory samples. The most common cause found in this study was clotted samples (59.1%). These results were similar to the study conducted by Ye *et al*. in China, where 57.2% of samples were rejected due to clotting.14 However, a similar study completed in Spain by Llopis *et al*. revealed 14.4% sample rejection during the first phase due to clotting.[15] The explanations behind clotted blood sample being highest among pre-analytical error may be attributed to mainly inadequate mixing in anticoagulant containing tubes or prolonged storage.[16]

In the present study, other pre-analytical errors in decreasing order of frequency were found to be inadequate samples (33.1%) followed by hemolysis (13.4%) and diluted samples, respectively. In a similar study conducted in Nepal in 2020, Inadequate samples were found to be (25%) of the total pre-analytical errors. In contrast, hemolysed samples constituted 20% of the total causes of pre-analytical errors[17]. In contrast to our results, Lippi *et al*. reported that hemolysis is the most common cause of sample rejection in a chemical laboratory (74.1%). Hemolysis may occur due to various reasons, vigorous emptying of a plunger into the sample tube and extended tourniquet application being a few of them.[18] The low frequency of hemolysis samples in the present study may be due to superior knowledge of blood collection procedure for workers doing phlebotomy procedure.

In the present study, after applying remedial measures, the frequency of pre-analytical errors decreased from 0.016% to 0.004%, almost a 25% improvement in error rate. Arslan *et al*. conducted a similar study, which showed an improvement in error frequency from 0.6 % to 0.5% after training.[19] This

improvement in error rate in both studies is due to the training of nurses and staff performing phlebotomy procedures. Intra-departmental communication is also the key factor to improvement in pre-analytical errors. One study by Berg *et al*. stated that the rate of hemolysis could be reduced by improving the phlebotomy technique used for blood collection.[20] In addition, pre-analytical testing errors can be significantly reduced by increasing the number of trained phlebotomy staff and periodically educating them.

CONCLUSION

This study indicates that the most frequent pre-analytical laboratory errors encountered in the haematology laboratory include clotted samples, insufficient quantity, hemolysed samples, diluted samples, lipemic samples and degenerated samples. It also underlines the significance of training the nursing and laboratory staff during the pre-analytical phase. It has shown a reduction in pre-analytical errors after corrective measures are implemented.

Conflict of Interest: None.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

AE & ST: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

FA & AS: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

SS & MWK: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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